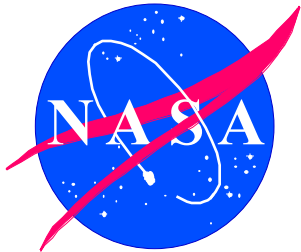


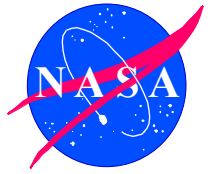
Runway Incursion Prevention System RIPS

**Demonstration and Testing at the
Dallas-Ft. Worth International Airport**



Denise Jones
RIPS Principle Investigator

NASA Langley Research Center
denise.r.jones@larc.nasa.gov



RIPS Goal and Testing Objectives

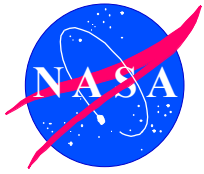


Aviation Safety Program - Runway Incursion Prevention Systems

Goal: To prevent runway incursion accidents through technologies that enhance surface situational awareness, navigation, and alerting for the pilot.

Objectives:

- Assess and validate technology performance for preventing runway incursion accidents
 - Collect data to assess the performance of the emerging incursion alerting algorithms, data link, GPS, and surveillance technologies
 - Validate system performance data against evolving RTCA standards for data links, LAAS/WAAS, surveillance, and database
- Demonstrate system in an operational environment
 - Integrate with the FAA Runway Incursion Reduction Program's (RIRP) DFW surface surveillance infrastructure
 - Conduct demonstrations for industry observation

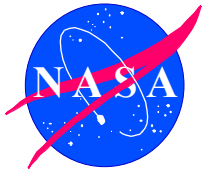


Related Research



Aviation Safety Program - Runway Incursion Prevention Systems

- Focused research at NASA on surface operations began in 1993 ...
 - Goal:
 - VMC capability in IMC to Category IIIB (*Aviation System Capacity Program*)
 - Runway incursion prevention (*Aviation Safety Program*)
 - Major milestones:
 - 1995, B-737 flight testing at FAA Technical Center, Atlantic City, NJ
 - 1997, B-757 flight testing at Hartsfield-Atlanta International Airport (ATL)
 - 1999, full-mission simulation evaluating Runway Incursion Alerting concept

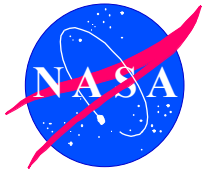


Runway Incursion Prevention Basic Needs



Aviation Safety Program - Runway Incursion Prevention Systems

- **Know exactly where you are**
- **Know exactly where other traffic is**
- **Know where you're supposed to go**
- **Alerting which makes errors/conflicts immediately obvious to all parties**



Approach: A Surface CNS System



Aviation Safety Program - Runway Incursion Prevention Systems

Tactical and strategic flight deck displays¹

Know exactly where you are -

- DGPS/INS + airport database
 - Supplemental guidance that is independent of visibility



Know exactly where other traffic is -

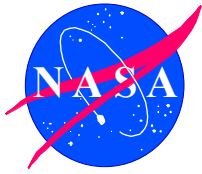
- Data link of traffic + airport database
 - Cockpit Display of Traffic Information (CDTI) supplements “see-and-avoid” and enables runway incursion alerting

Know where you're supposed to go -

- Data link of ATC instructions + airport database
 - Controller-Pilot Data Link Communications (CPDLC) enables unambiguous routing and route monitoring



¹ Using existing display devices (HUD and ND)



Runway Incursion Prevention System (RIPS)



Aviation Safety Program - Runway Incursion Prevention Systems

- Demonstrate/evaluate a prototype RIPS to improve safety on the airport surface, thus leading to elimination of RI accidents.



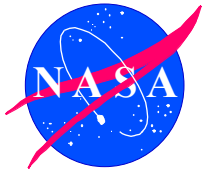
“Runway Conflict”



HUD Guidance



Electronic Moving Map

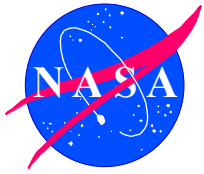


Incursion Alerting Methods



Aviation Safety Program - Runway Incursion Prevention Systems

- Three methods of generating runway incursion alerts
 - Aircraft based alerting algorithms developed by Rannoch Corp. – Runway Incursion Advisory and Alerting System (RIAAS)
 - Aircraft based alerting algorithms developed in-house – Integrated Display System (IDS)
 - Alerts generated by FAA surveillance system and transmitted to aircraft – Ground Based System (GBS)
- Runway Traffic Alert (RTA) – Cautionary, Pilot action not required
 - Part of RIAAS only
- Runway Conflict Alert (RCA) – Warning, Avoidance maneuver required
 - Provided for all three alerting methods
- Each method evaluated simultaneously
- One source chosen for display in cockpit

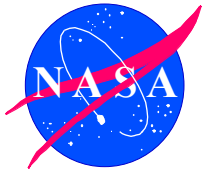


RIPS Potential Benefits



Aviation Safety Program - Runway Incursion Prevention Systems

- Providing runway incursion alerts, supplemental guidance cues, supplemental situational awareness, and controller/pilot data link communications directly to the flight crew results in the following benefits:
 - *Improved Prevention*
 - *Improved Detection*
 - *Improved Response*

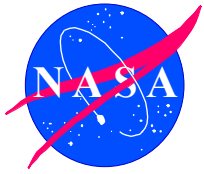


NASA B-757 Research Aircraft



Aviation Safety Program - Runway Incursion Prevention Systems



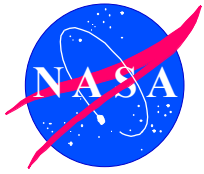


RIPS Partners/Contractors



Aviation Safety Program - Runway Incursion Prevention Systems

- *Federal Aviation Administration*
 - *Volpe National Transportation System Center* - surveillance server
 - *TRIOS Associates* - data link manager, test van
 - *Ohio University* - LAAS ground station, CPDLC
 - *Sensis* - multilateration system
 - *CACI* - surveillance sensor fusion
- *Rockwell-Collins Avionics* - ADS-B, onboard LAAS
- *Ohio University* - controller workstation
- *Rannoch* - incursion alerting algorithm
- *Jeppesen-Sanderson* - DFW data base



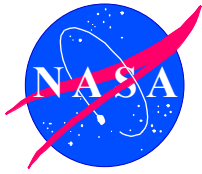
DFW System Components



Aviation Safety Program - Runway Incursion Prevention Systems

Airborne

- Incursion Detection Algorithms
- Electronic Moving Map on navigation display
- HUD
- Audible alerting system
- Data Link Systems
 - Automatic Dependent Surveillance - Broadcast (ADS-B) - 1090
 - Traffic Information Service - Broadcast (TIS-B) - Universal Access Transceiver (UAT)
 - Controller Pilot Data Link Communications (CPDLC) - VDL Mode 2
 - Local Area Augmentation System (LAAS) corrections - VDB
- LAAS receiver
- Wide Area Augmentation System (WAAS) receiver

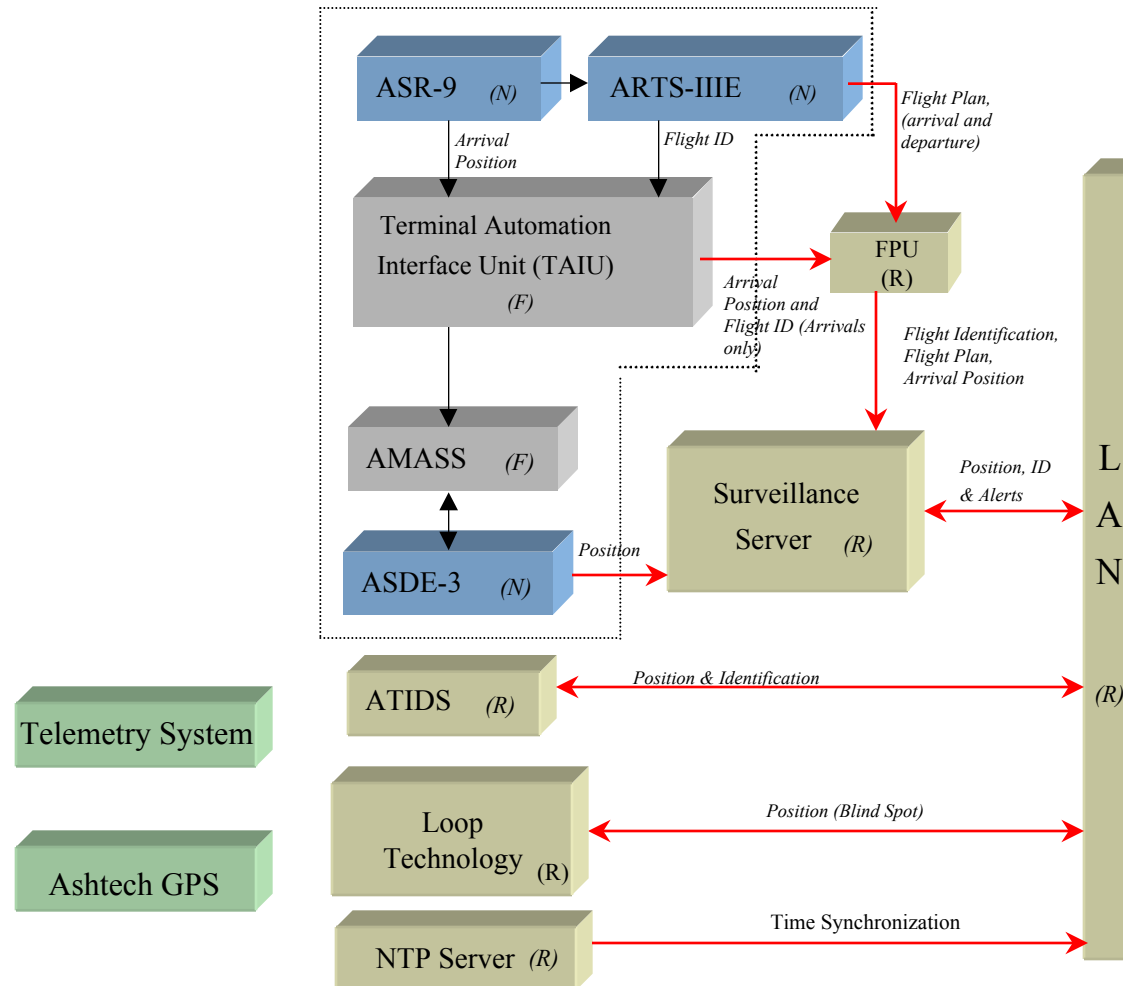


FAA RIRP Surface Architecture

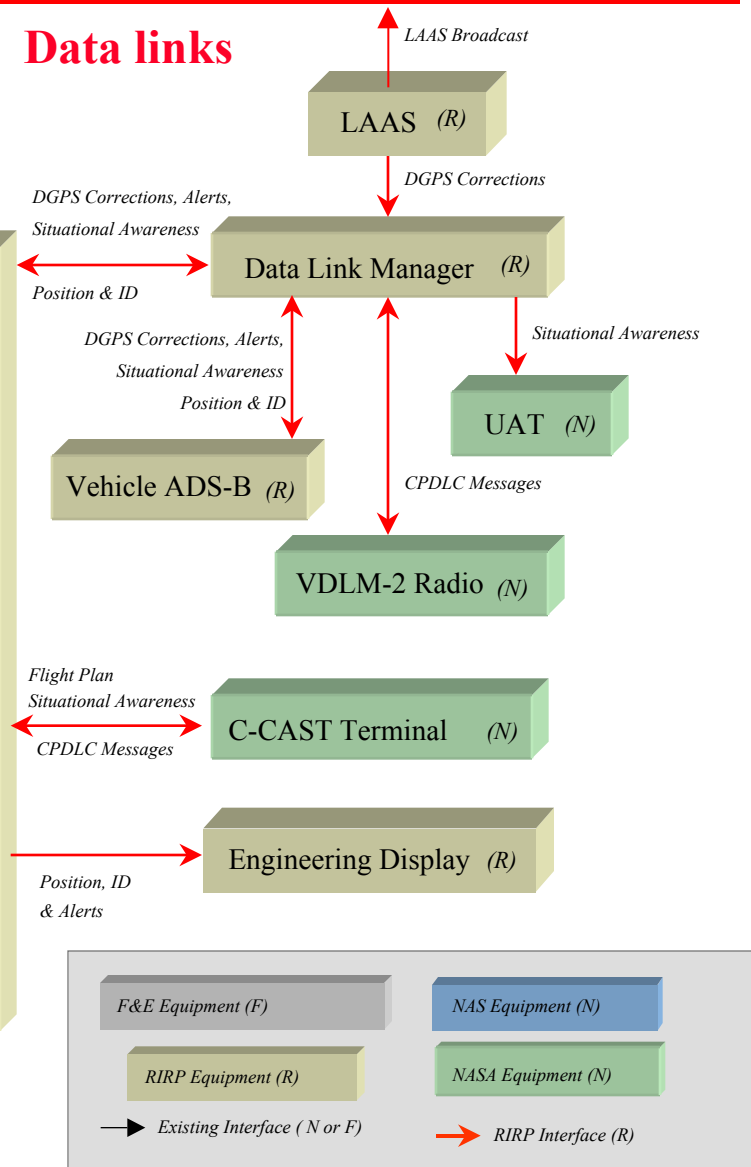


Aviation Safety Program - Runway Incursion Prevention Systems

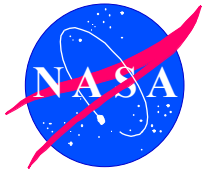
Surveillance Sources



Data links



Volpe - Trios - Sensis - CACI - Ohio University

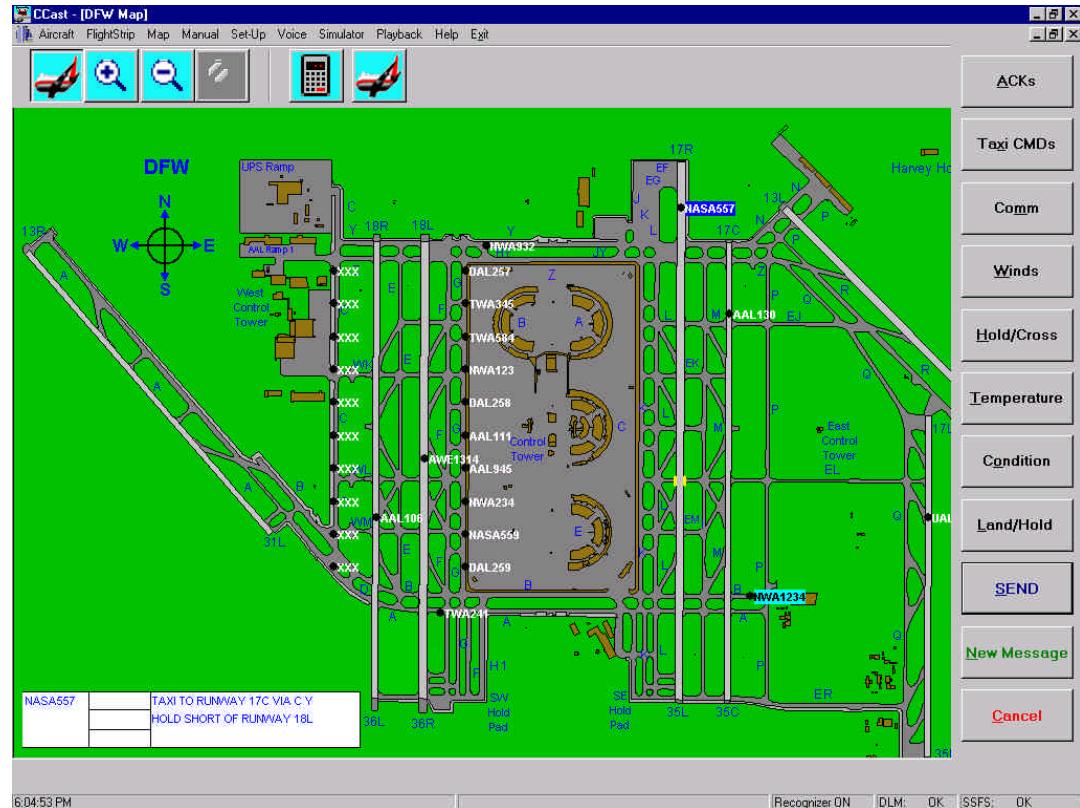


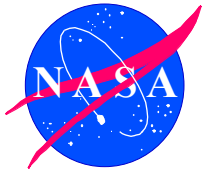
Controller Communication and Situational Awareness Tool (C-CAST)



Aviation Safety Program - Runway Incursion Prevention Systems

- ICAO ATN-type messages for Surface Ops
 - Taxi routes
 - Hold Short
 - COMM
 - ATIS info
- Downlink/ display Runway Incursion alerts and deviations
- Voice recognition/ touchscreen input
- VDL Mode 2 datalink
 - Traffic display w/holdbars & alerts
 - Flight Strips w/ uplinks & downlinks



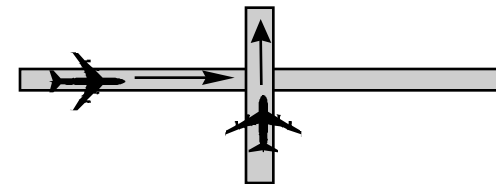
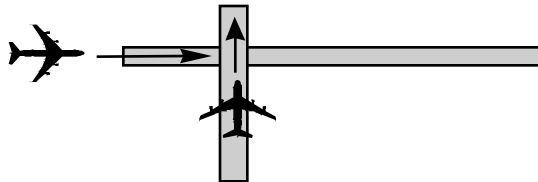


RIPS Operational Scenarios



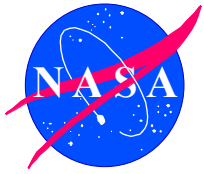
Aviation Safety Program - Runway Incursion Prevention Systems

- Runway incursion emulations
 - Evaluate alert generation methods
 - NASA B-757 and test vehicle
 - Takeoff, landing, and taxi scenarios
 - Scenarios scripted and briefed



* Most frequently occurring types of incursions (MIT Lincoln Laboratory, 1994)

- Gate-to-gate operations
 - Evaluate incursion avoidance due to blunder



Test Van



Aviation Safety Program - Runway Incursion Prevention Systems

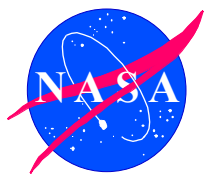


Test Vehicle Conducting 1090 RF Measurements

Provides a mobile test platform for the verification and analysis of surface surveillance systems.

Equipped with:

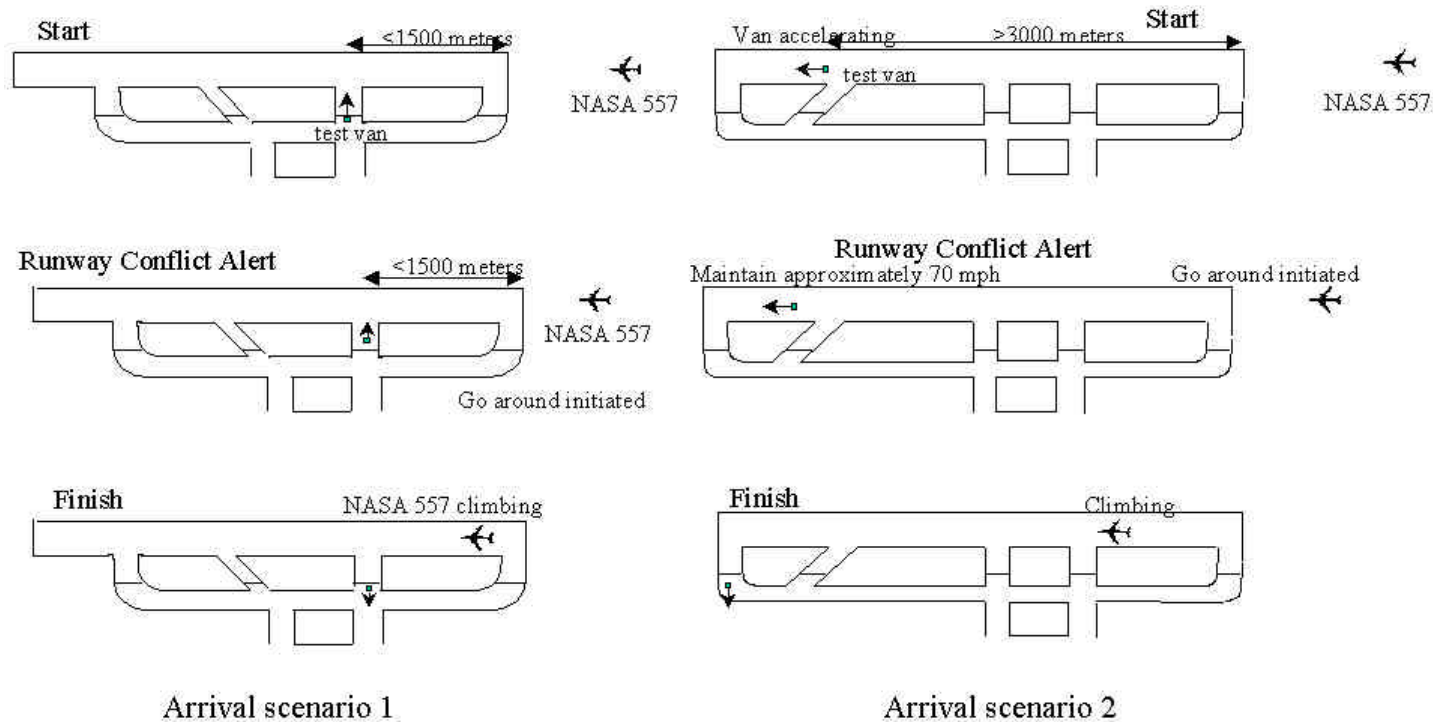
- ADS-B Mode-S Transponder
- ATCRBS transponder
- UPSAT Capstone Suite (UAT)
- Generator
- Rackmount PCs, Printer, LAN
- Dual VHF Radio
- 400Hz Aviation Power Supply

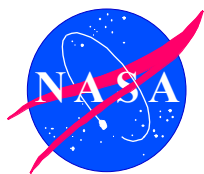


Experiment/Demonstration Scenarios



Aviation Safety Program - Runway Incursion Prevention Systems

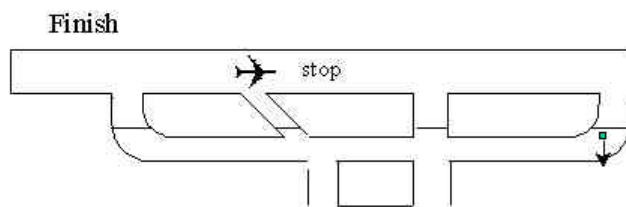
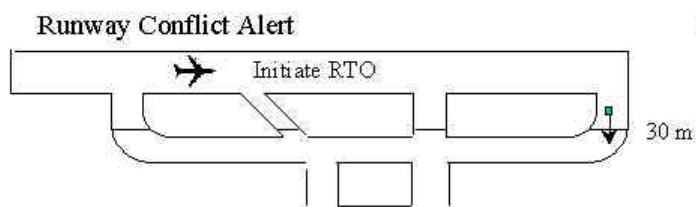
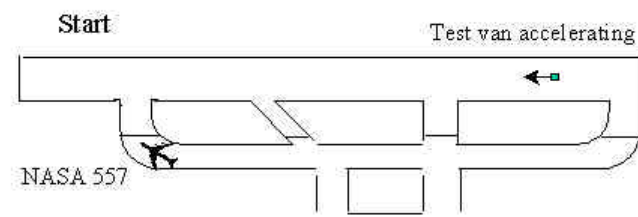
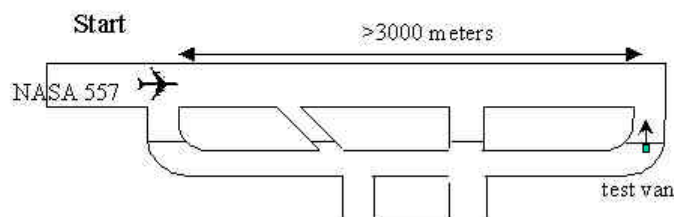




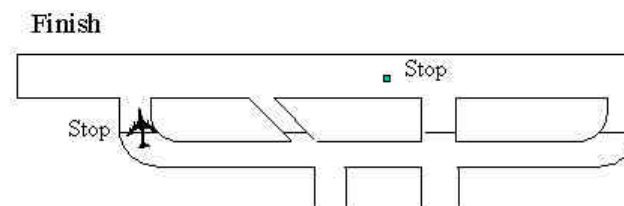
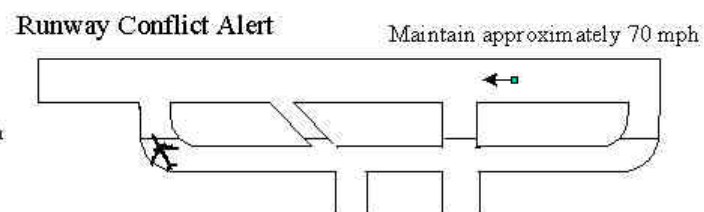
Experiment/Demonstration Scenarios



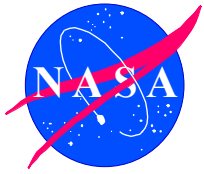
Aviation Safety Program - Runway Incursion Prevention Systems



Departure Scenario 1



Departure Scenario 2

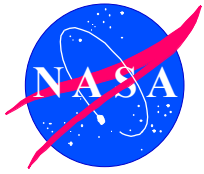


Test Matrix



Aviation Safety Program - Runway Incursion Prevention Systems

- 4 airline captains as subject pilots
- 51 RIPS test runs
- Objective and subjective data collected
- Video and audio recorded for each run

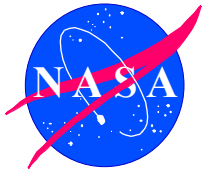


Subject Pilot Comments



Aviation Safety Program - Runway Incursion Prevention Systems

- In general -
 - Felt safer with RIPS onboard
 - RIPS alerting timely
 - Prefer no more than one or two audible alerts
 - No need for two stage alerting
 - Display of distance and time to incurring traffic not necessary
 - Prefer maneuver guidance when taxiing across a runway
 - Impressed with Electronic Moving Map for surface situational awareness - “Best thing since sliced bread”



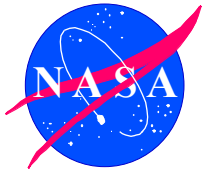
Preliminary Observations



Aviation Safety Program - Runway Incursion Prevention Systems

With this architecture, in general:

- Initiation of alerts relative to time were as follows:
 - IDS and RIAAS RTA
 - RIAAS RCA
 - GBS
- Aircraft based alerting provided more timely alerting for the flight crew than transmitting the ground based alerts to the aircraft. This was primarily due to the time latency of transmitting the information over the data link.
- The flight testing has demonstrated the feasibility of providing aircraft based runway incursion alerting.

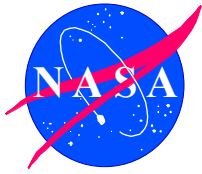


Next Steps



Aviation Safety Program - Runway Incursion Prevention Systems

- Further integration of surface situation awareness and runway incursion alerting into Synthetic Vision system concepts.
- RTCA Special Committee 193/ EUROCAE Working Group 44 standards for certifiable Terrain and Airport Databases
- Technology transfer to industry
 - Surface guidance/awareness concept to Rockwell Collins
 - Alerting algorithm available to FAA Safe Flight 21/Runway Safety Program
- Safe Flight 21 cooperative efforts
 - Louisville demonstration on Oct. 30, 2000
 - Memphis Tech Eval in spring 2001



Acronym List



Aviation Safety Program - Runway Incursion Prevention Systems

ADS-B	Automatic Dependent Surveillance-Broadcast	HSALT	Hold Short Advisory Landing Technology
ASDE-3	Airport Surface Detection Equipment	HUD	Head-Up Display
ATC	Air Traffic Control	IDS	Integrated Display System
ATIDS	Airport Traffic Identification System	INS	Inertial Navigation System
C-CAST	Controller Communication and Situational Awareness Tool	LAAS	Local Area Augmentation System
CDTI	Cockpit Display of Traffic Information	LAHSO	Land and Hold Short Operations
CDU	Control Display Unit	ND	Navigation Display
CFIT	Controlled Flight Into Terrain	PFD	Primary Flight Display
CNS	Communication, Navigation, and Surveillance	PI	Principle Investigator
CPDLC	Controller-Pilot Data Link Communications	RCA	Runway Conflict Alert
DAS	Data Acquisition System	RI	Runway Incursion
DFW	Dallas-Fort Worth International Airport	RIAAS	Runway Incursion Advisory and Alerting System
DGPS	Differential Global Positioning System	RIPS	Runway Incursion Prevention System
DPDS	Data Processing and Display System	RIRP	Runway Incursion Reduction Program
EDCP	Experimental Display Control Panel	RTA	Runway Traffic Alert
EMM	Electronic Moving Map	SA	Situational Awareness
EVS	Enhanced Vision System	sTIS-B	Surface Traffic Information Service-Broadcast
FDRS	Flight Deck Research Station	SVS	Synthetic Vision System
FLIR	Forward-Looking Infra-Red	TCAS	Traffic Alerting and Collision Avoidance System
FMS	Flight Management System	TRS	Transport Research System
GA	General Aviation	UAT	Universal Access Transceiver
GPS	Global Positioning System	VDB	Very High Frequency (VHF) Data Broadcast
		VDL	VHF Data Link
		WAAS	Wide Area Augmentation System